

20. Kölner Sonnenkolloquium, 6. Juli 2017

Thermochemical storage of solar energy through reversible redox-reaction

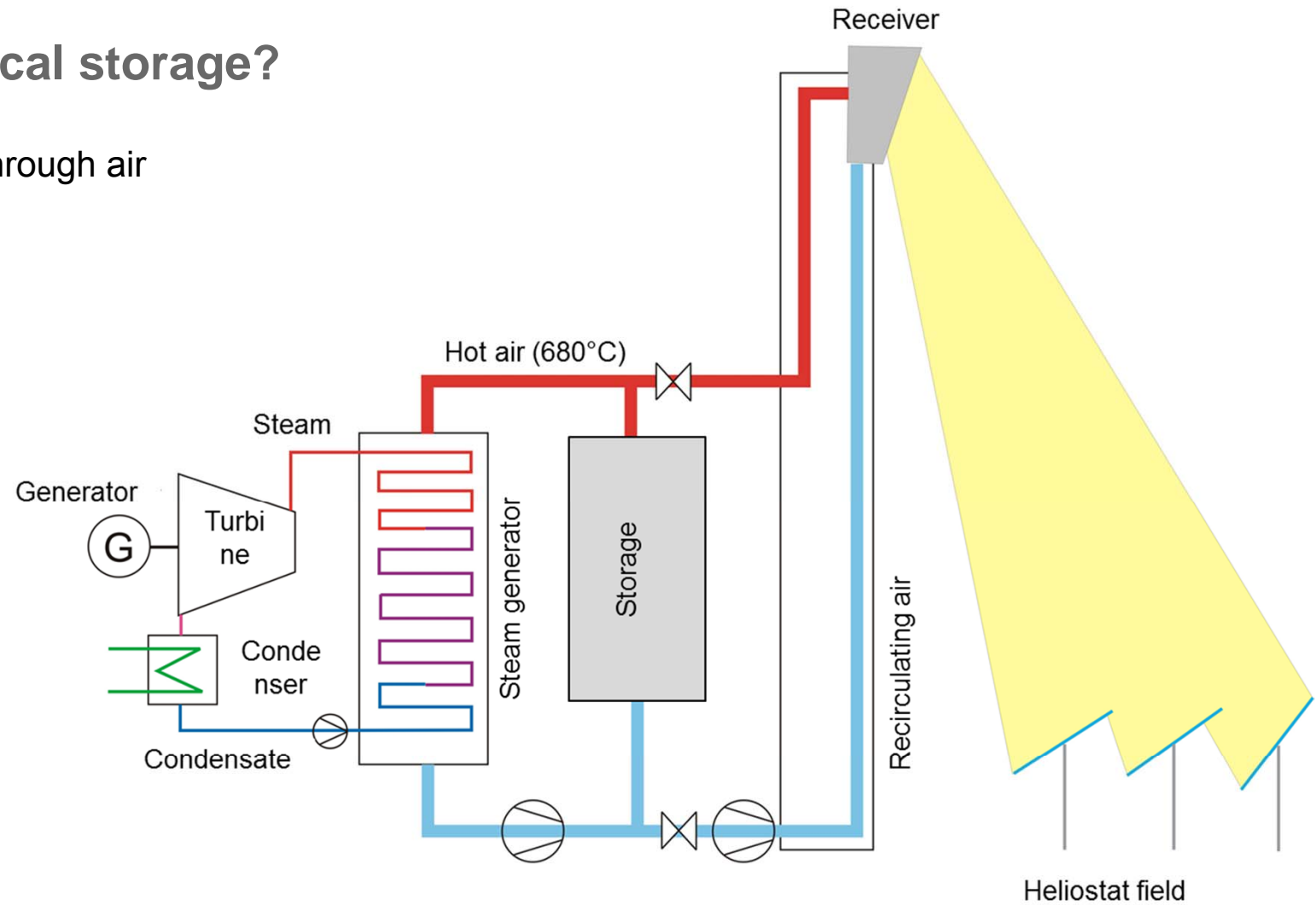
S. Tescari, A. Singh, L. de Oliveira,
S. Breuer, C. Agrafiotis,
M. Roeb, C. Sattler,

A large, curved image of the Earth from space occupies the bottom right portion of the slide. It shows a view of the Earth's surface with blue oceans, green landmasses, and white clouds. The curve of the horizon is visible at the top of the image.

Knowledge for Tomorrow

Why thermochemical storage?

- Charge and discharge through air
- Power Turbine 1.5 Mw_e
- Storage



Why thermochemical storage?

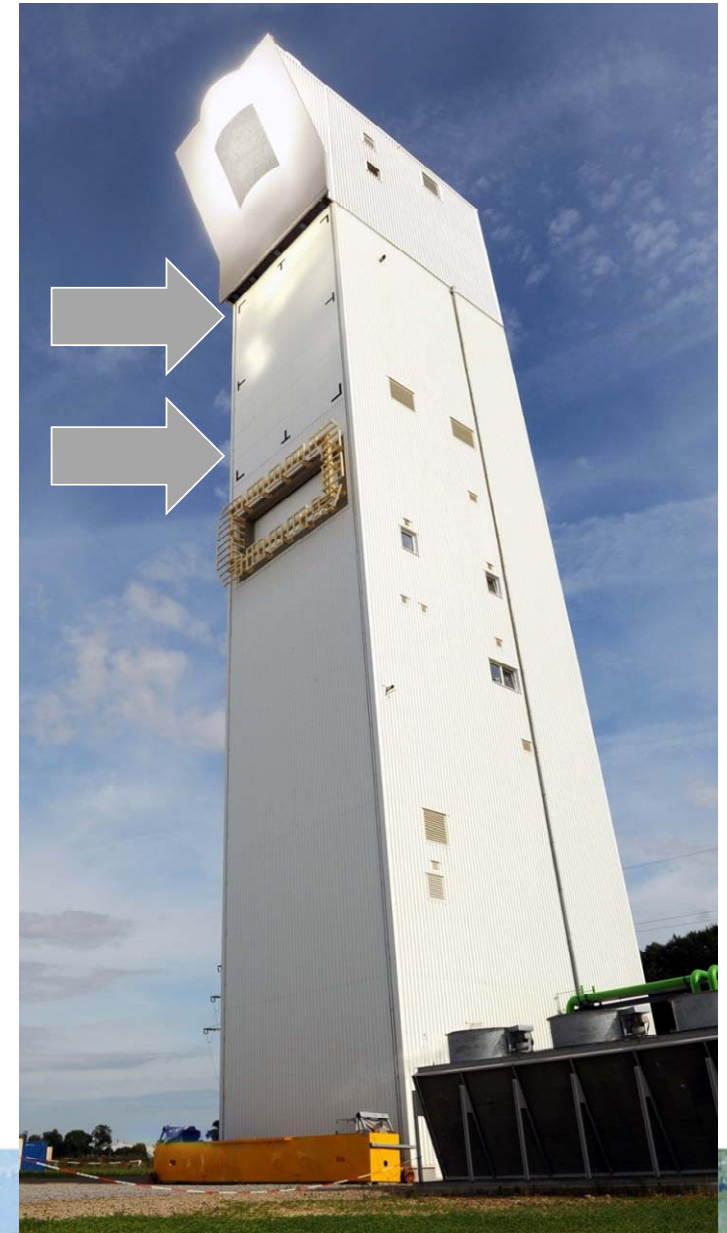
- Charge and discharge through air
- Power Turbine 1.5 Mw_e
- Storage:
- Ceramic honeycombs
- Capacity: 1.5h at full power
- Storage dimension: 6 x 6 x 7 m



[Zunft et al. 2009]

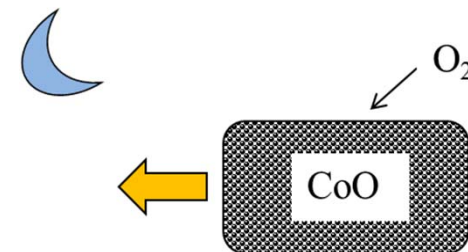
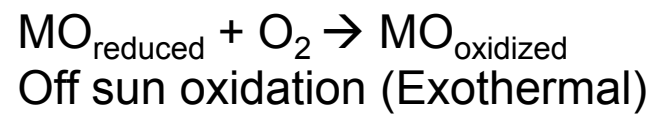
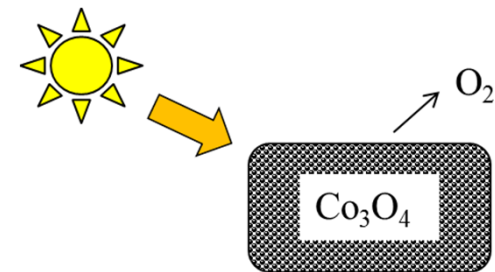
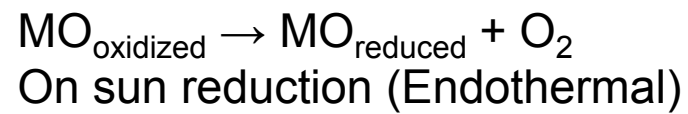


[Zunft et al. 2010]

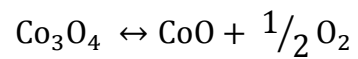
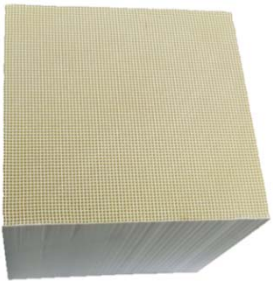


CONCEPT:

Thermo-Chemical Storage by 2-steps Red-ox cycles:

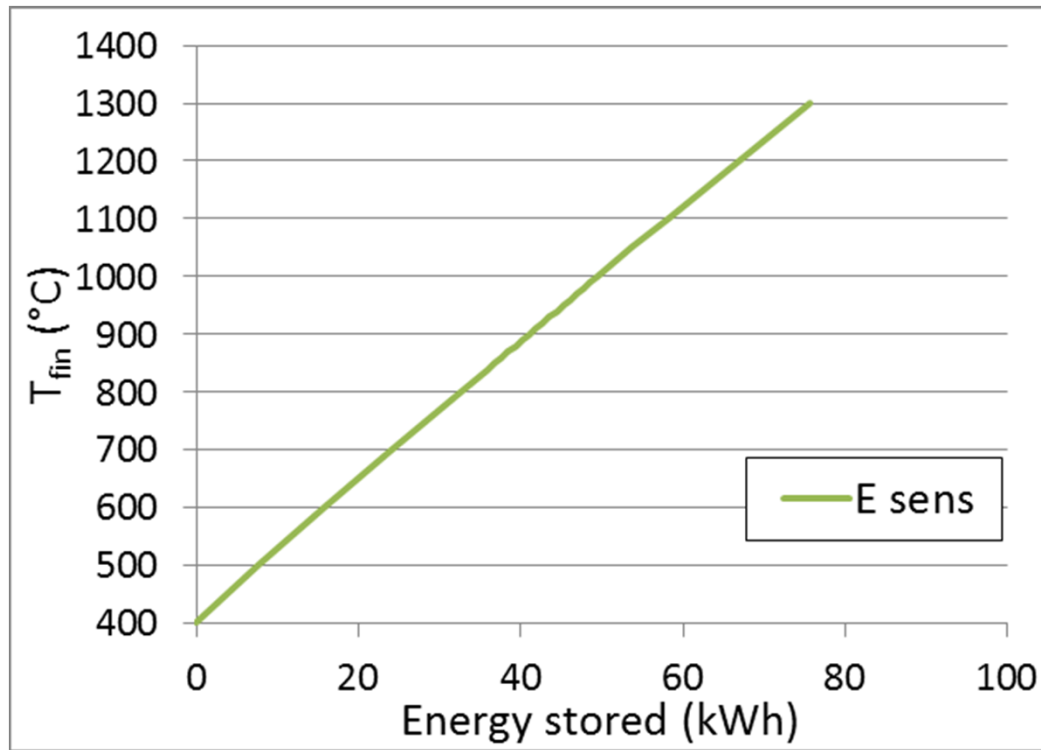


Basics



$$\Delta H_{298.15\text{ K}} = 844 \text{ kJ/kg}$$

$$T_{eq} = 890^\circ\text{C}$$



$$Q_{sens} = m \cdot c_p \cdot (T_{fin} - T_{in})$$

$$Q_{chem} = m \cdot f \cdot \Delta H$$

$$Q_{stored} = Q_{sens} + Q_{chem}$$

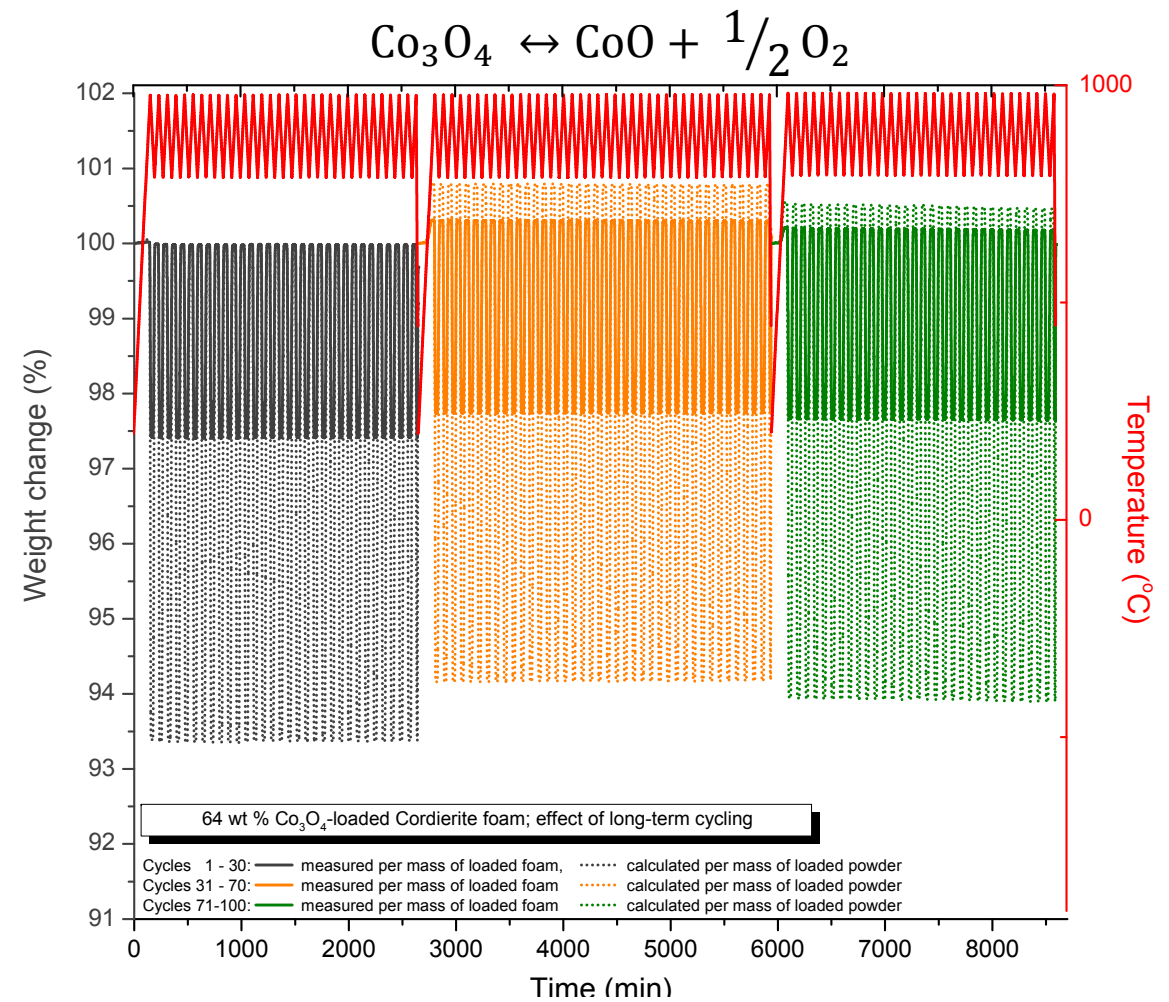
Other advantages:

- Constant temperature
- Possible long term storage



$m_{\text{Co}_3\text{O}_4} = 100 \text{ mg, 100g, 100kg}$

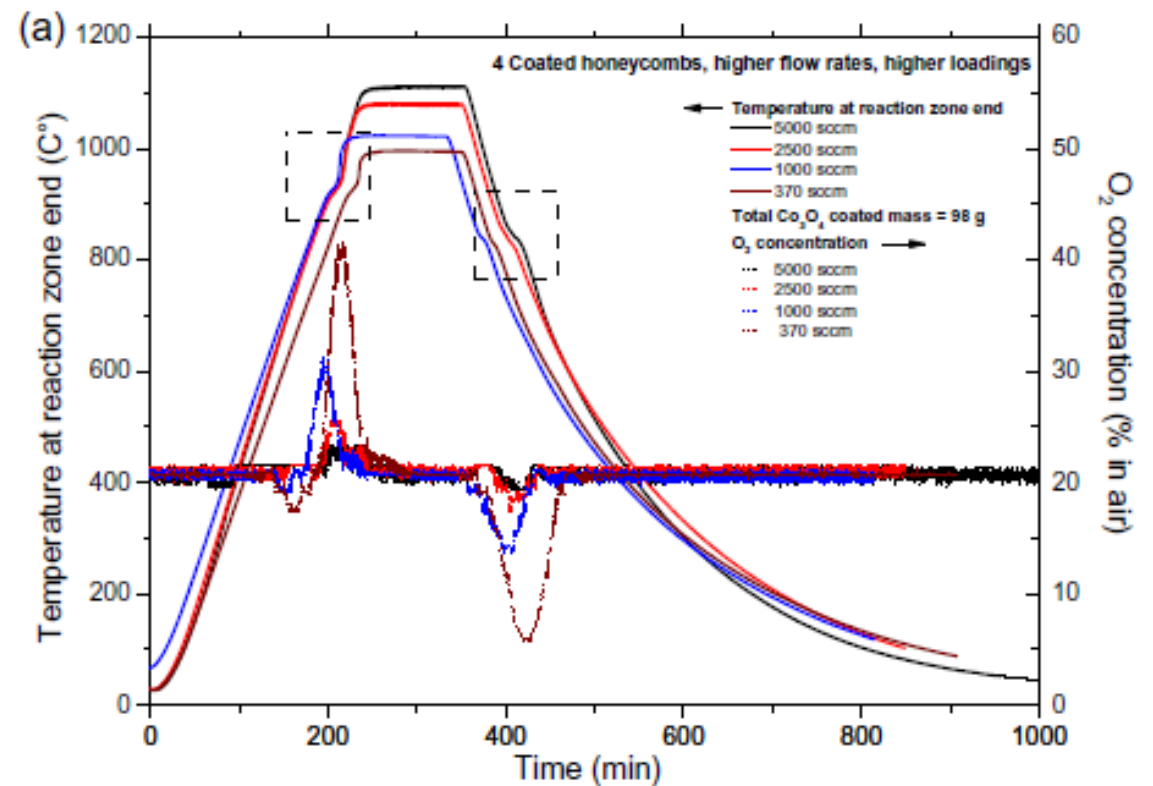
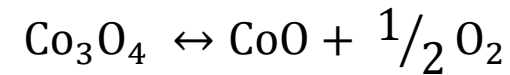
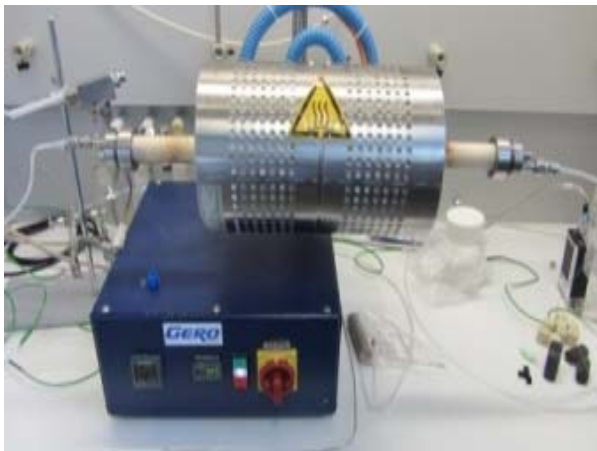
TGA experiments



100 cycles; no activity loss

$$m_{\text{Co}_3\text{O}_4} = 100 \text{ mg, } 100\text{g, } 100\text{kg}$$

Lab-scale furnace



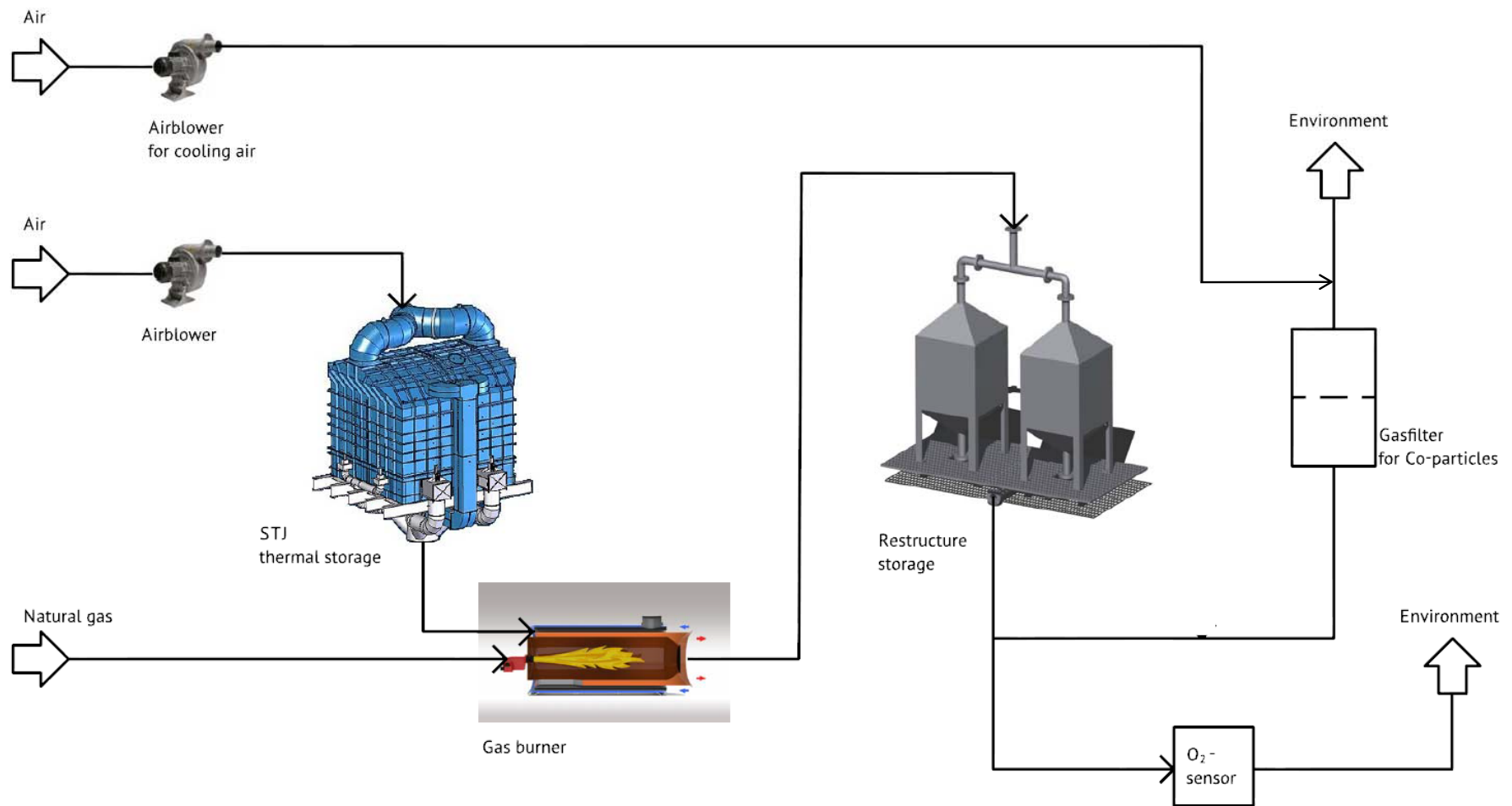
At lab-scale reaction is only chemically visible

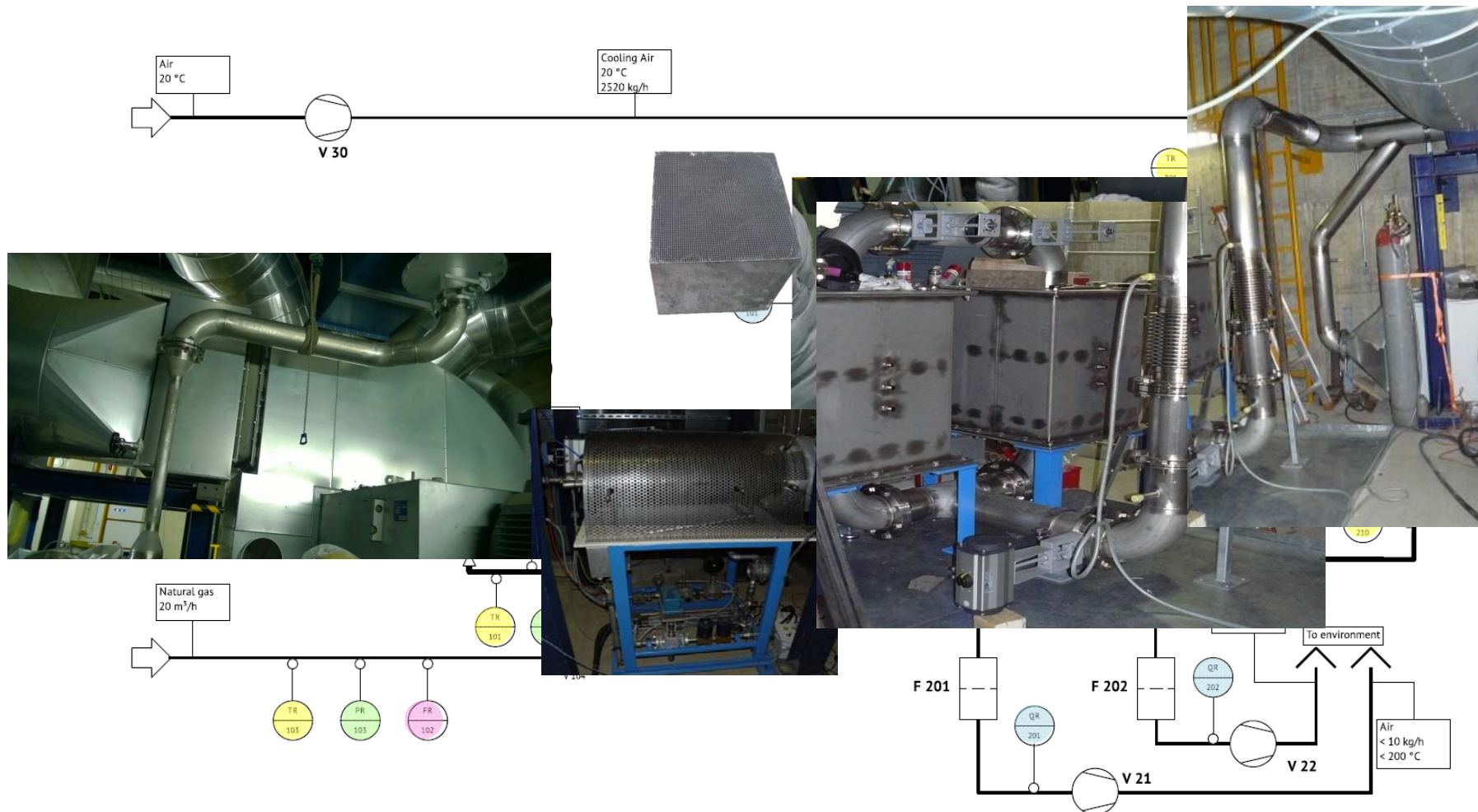
$$m_{\text{Co}_3\text{O}_4} = 100 \text{ mg, } 100\text{g, } 100\text{kg}$$

Pilot-scale reactor

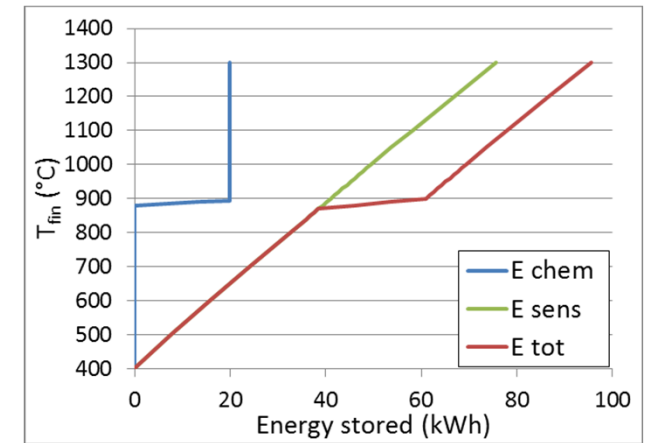
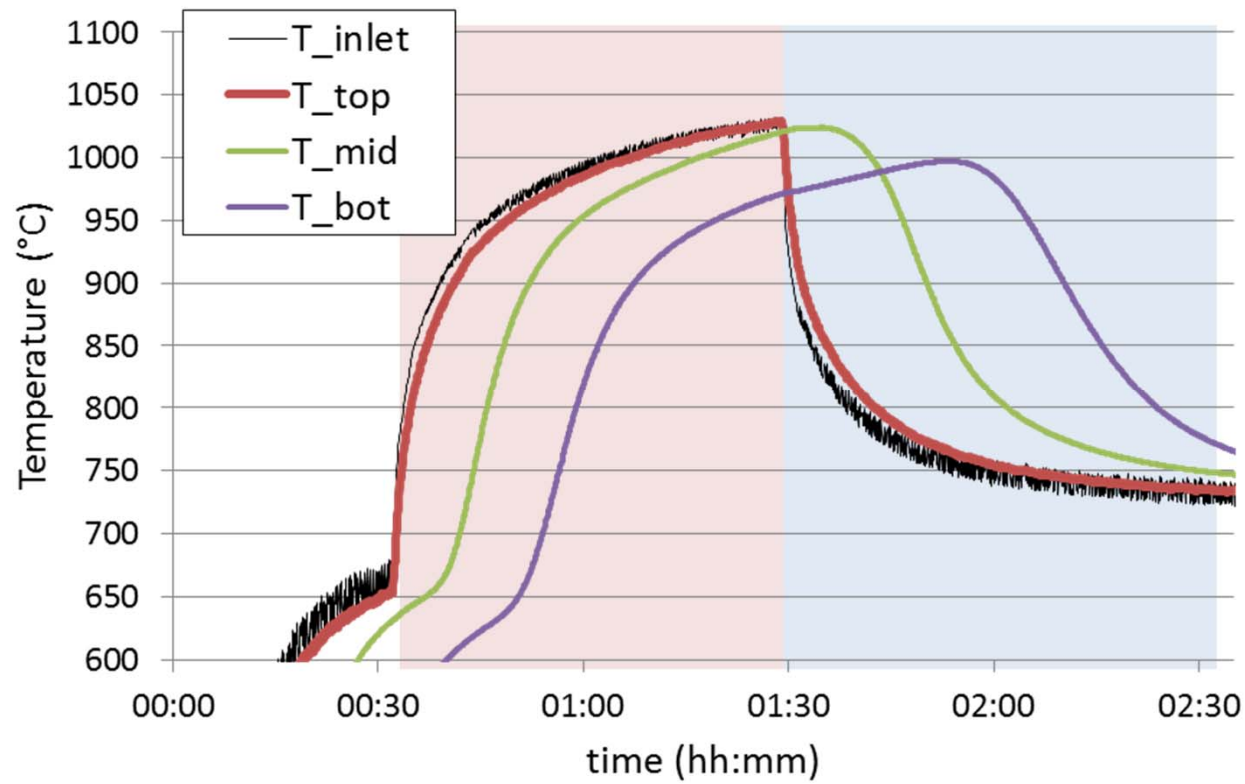
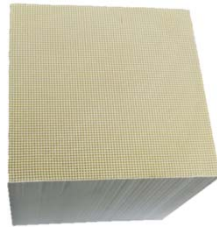
- Two chambers
- Dimensions: 0.8 x 0.6 x 0.6
- Total number of HC: 128
- $\text{Mass}_{\text{cobalt}} = 90 \text{ kg}$
- $\text{Mass}_{\text{tot}} = 280 \text{ kg}$



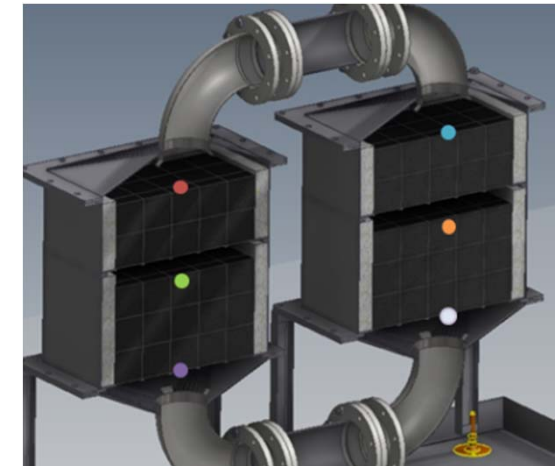
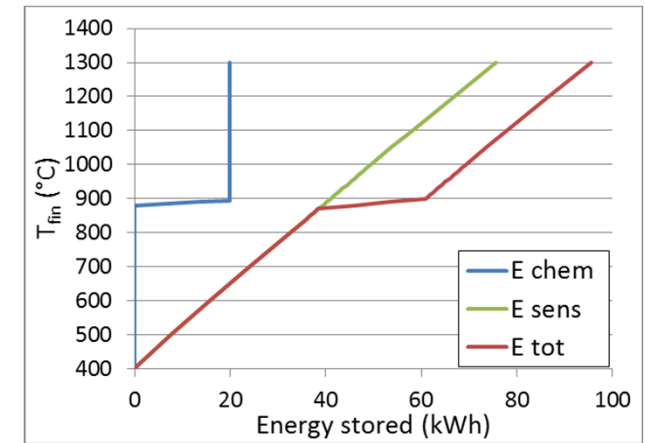
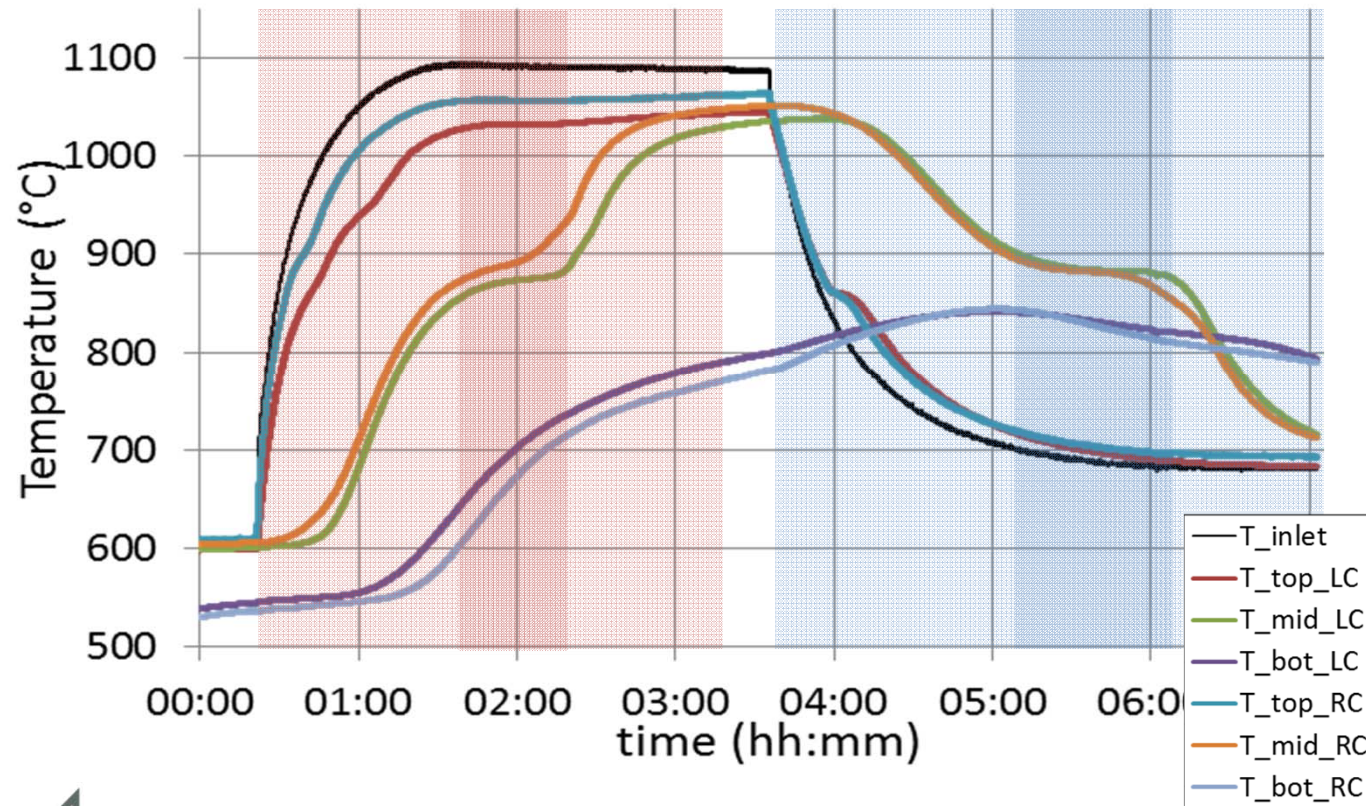




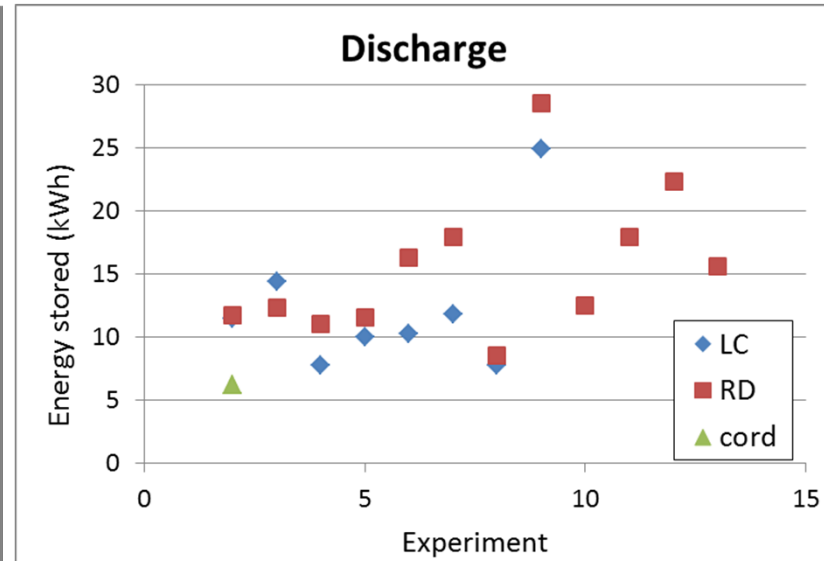
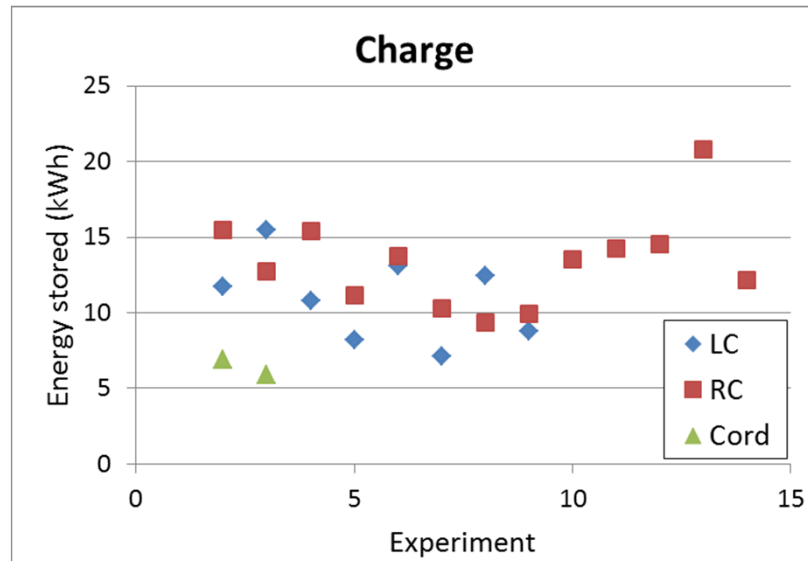
Thermal Tests



Chemical Tests



Experimental results



Stored energy (kWh)	
thermo-chemical	13.2
thermal	6.3

Double energy density
Efficient heat release
no performance degradation



Achievements

- The heat effect of the chemical reaction was clearly detected
- The storage capacity was doubled by the occurrence of the chemical reaction
- A constant temperature higher than T_{react} could be obtained during most of the discharge phase
- 22 cycles were carried out without performance degradation

Outlook

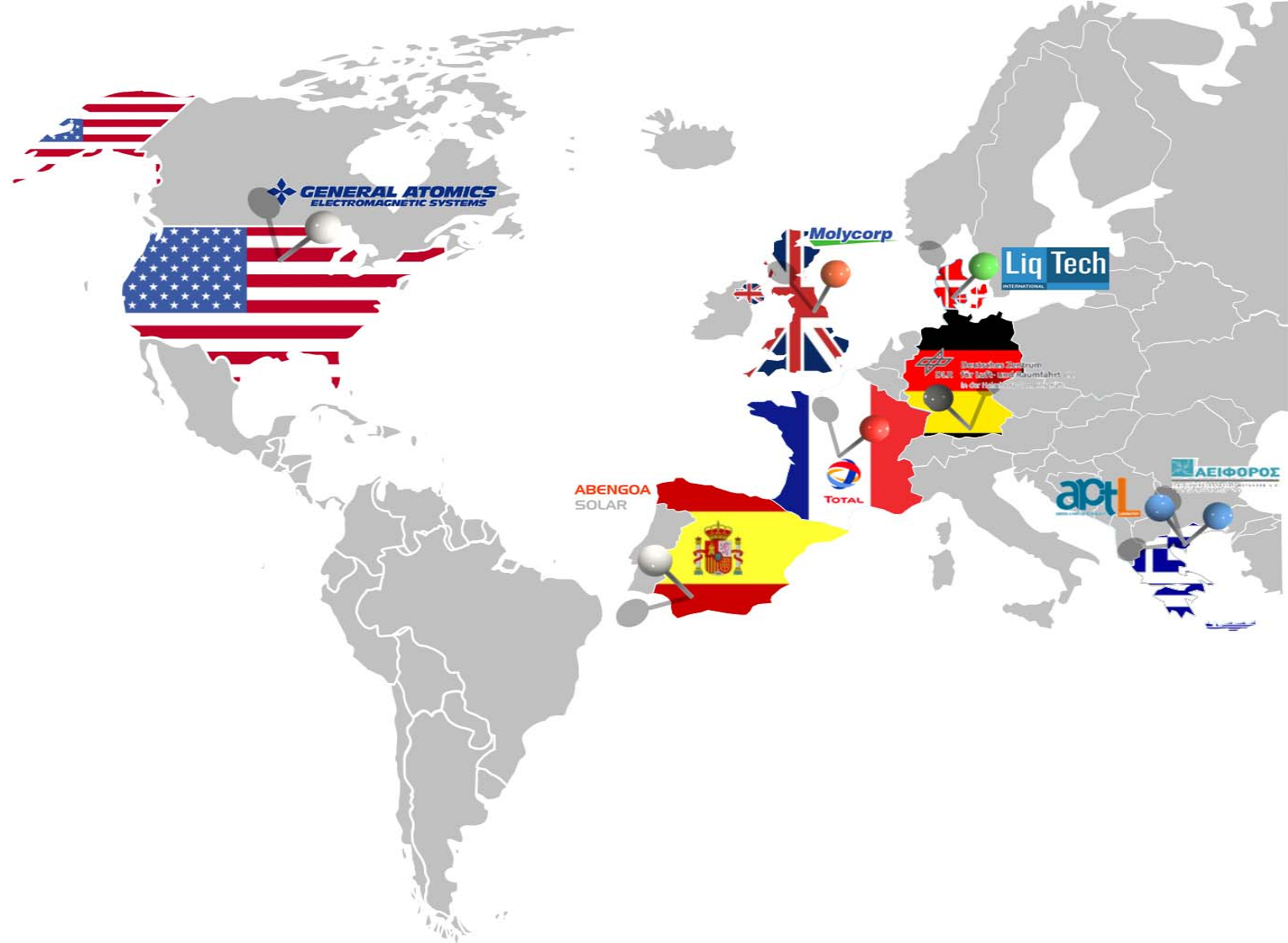
- Further technology development (follow-up project)
- Bigger scale
- Search for other applications of TCS





Acknowledgements:

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RESTRUCTURE –contract
n° 283015” under the
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Thanks for your attention

